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Request for grant of a Patent Form 1/77

Patents Act 1977

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- 1 Please give the title of the invention
- HYBRID ELECTRICITY AND
TELECOMMUNICATIONS DISTRIBUTION
NETWORK

2 Applicant's details

☐ First or only applicant

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Corporate name NORWEB PLC

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Continuation sheets for this Patents Form 1/77

Claim(s)

Description

Abstract

Drawing(s)

30

13

8b Which of the following documents also accompanies the application?

Priority documents (please state how many)

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Patents Form 7/77 – Statement of Inventorship and Right to Grant (please state how many)

Patents Form 9/77 – Preliminary Examination/Search

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1

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DUPLICATE

HYBRID ELECTRICITY AND TELECOMMUNICATIONS

DISTRIBUTION NETWORK

This invention relates to a method of signal injection,
transmission, interconnection (termination), and
5 detection, and to a power transmission network ie. a
mains electricity distribution and/or transmission
network, and a filter therefore. In particular it
relates to the use of electricity transmission networks
and/or lines for telecommunications transmission (e.g.
10 voice and/or data).

In the UK, it is conventional to describe a power network
for 33kv and above as a "transmission network", and one
for less than 33kv as a "distribution network". In this
specification the term "electricity distribution and/or
15 power transmission network" is normally used, but general
references to power networks and to transmission of
signals are to be construed as applying to all such
networks.

Traditionally telecommunications signals have been
20 transmitted on independent networks e.g. telephone lines.
More recently, in order to simplify and increase
efficiency of telecommunications services to domestic or
industrial premises, there have been investigations into
using existing electricity transmission and distribution

networks to carry telecommunications services.

A transmission network and a filter therefore is described in the applicant's co-pending International Patent Application, PCT/GB93/02163. This describes the
5 use of telecommunications signals having a carrier frequency greater than around 1MHz on a power transmission network. The teaching and disclosure of that patent application should be referred to in relation to the present invention, and is incorporated herein by
10 reference.

At such carrier frequencies, it has been found that the cables of a power transmission and/or distribution network exhibit pseudo-coaxial characteristics and therefore attenuation of a signal transmitted along the
15 cables is reduced. In this way, both speech and data signals can be transmitted at carrier frequencies of greater than approximately 1MHz, allowing for a larger available spectrum and greater transmission capacity.

However, it has been found that the attenuation effects
20 still limit the distance over which signals of a given carrier frequency and bandwidth can effectively be transmitted. On, for example, a 415 volt network the carrier frequency may preferably be between 1-10 MHz, and on, e.g., an 11KV network maybe between e.g. 1-20 MHz or

possibly 5-60 MHz. Signals of this frequency can be transmitted over large distances (using repeater stations if necessary) and therefore a network used in this way is suitable for general telecommunications and telephony signals.

However broadband telecommunication signals, such as television communications, generally require a higher carrier frequency (or frequencies) and bandwidth. As indicated above, such signals are therefore usually transmitted on an independent telecommunication network e.g. co-axial cable, optical fibre etc.

A carrier frequency of up to hundreds of MHz may be used on a network as described in PCT/GB93/02163, although the distance over which such a signal may be transmitted is limited - possibly to around 10-20 metres.

The present invention aims to provide a transmission network which alleviates some or all of the above problems.

Accordingly, in a first aspect, the present invention provides a signal transmission network including at least one telecommunications network portion and at least one power transmission and/or distribution network portion.

In a second aspect, the present invention provides an power transmission and/or distribution network including input means for the input of a telecommunication signal onto the power transmission network, (e.g. an electricity
5 transmission and/or distribution network) from a telecommunications network, and output means for removal of a similar telecommunication signal from the power network.

In this way, the independent (preferably external)
10 telecommunications network can be used to propagate the telecommunication signal over a long distance, with the (preferably external) power transmission/distribution network being used to propagate the telecommunication signal from the telecommunications network into e.g. the
15 premises of a user.

By "external", it is meant that the signal transmission network i.e. power network and/or telecommunications network is external to any building or premises such as an office or house. Inside such buildings, transmission
20 distances are typically short and therefore attenuation losses relatively unimportant.

The telecommunications network may be a standard broadband distribution network e.g. a coaxial or fibre cable. Such telecommunications networks are currently

available in most major countries. However, typically, the greatest cost and inconvenience associated with such telecommunications networks is not the initial installation of the main network but the connection of
5 the main network to the premises of users. The present invention allows the existing power transmission networks (which commonly feed into most suitable premises) to be used to connect the existing telecommunications network to the desired premises. Thus the additional cost and
10 inconvenience of installing further standard telecommunications network is avoided.

Typically, the distance between the existing telecommunications network infrastructure and the premises to which it is desired to be connected is short.
15 Therefore broadband telecommunication signals may be transmitted over the power transmission/distribution network without attenuation losses having any significant effect.

Preferably the telecommunication signal has a carrier
20 frequency greater than approximately 1MHz. The carrier frequency may in fact be less than 1MHz ie. 800KHz or even as low as 600KHz, but as it is reduced so is the bandwidth. The term "carrier frequency" refers to the unmodulated frequency of the carrier signal, and not to
25 the frequency of the telecommunication signal once

modulated.

A plurality of telecommunications signals may be provided, each having different carrier frequencies.

The power network may include one or more phases, and may
5 be a polyphase network including e.g. any one or more of
2, 3, 4, 6, 7 etc phases. Different sections of the
network may include different numbers of phases.

Preferably the power network is a single phase network
e.g. consisting of one or more single phase cable(s)
10 connecting one or more customers building(s) or premises
to a main polyphase (e.g. 3 phase) portion of the
electricity distribution network.

The broadband telecommunication signals are taken e.g.
via a tap, from the main broadband distribution network
15 (e.g. coaxial or fibre cable) via a suitable interface
unit and fed into the customer's single phase cable via
a suitable conditioning unit. The signal may be
amplified if necessary.

Preferably the power network is unbalanced i.e. provides
20 unbalanced transmission characteristics. The cable(s) of
the power network may be screened or clad e.g. with a
suitable metal material, which enables the cable to

behave as a pseudo-coaxial element to provide an unbalanced transmission network at the transmission frequency of the present invention.

Preferably the power network is a major (e.g. overground
5 and/or underground) power network including e.g. any or all of 132kv, 33kv, 11kv, 415v and 240v sections. The voice and data signals may be transmitted over any or all of the sections of the power network by suitable detection, amplification and/or regeneration and
10 reintroduction as and when necessary.

In preferred embodiments, full duplex facilities are provided i.e. signals may be transmitted and/or received in all directions simultaneously.

A network according to the first aspect of the present
15 invention may be used for many speech and/or data transmission purposes, such as remote reading of electricity meters, remote banking and shopping, energy management systems, telephony (voice), switched telephony, security systems and/or interactive data
20 services, multimedia services and television.

The present invention also provides a communications apparatus (known hereinafter as a "network conditioning unit") for use with a network according to the above

aspects of the present invention. The network conditioning unit includes a low pass filter portion or portions for filtering out the low frequency high amplitude mains power signal i.e. separating it from the telecommunication signal(s) and allowing it to pass through the conditioning unit. The unit also includes a coupling element for input and removal of telecommunication signals from the network and, preferably, a terminating element of similar impedance to the characteristic impedance of the network at that point.

The use of such a unit ensures that the high frequency telecommunications signals do not contaminate the internal low voltage wiring present inside a premises, and/or that noise sources from the internal low voltage premises wiring do not contaminate or corrupt the high frequency telecommunications signals being transmitted over the external electricity transmission and/or distribution network.

Preferably, the variable electrical loading effects (i.e. the load impedances) of all items which are coupled onto the network, from time to time and which utilise electrical energy (i.e. the electrical loads) are isolated from the communications signals by the action of low pass filter element(s) of the conditioning unit(s).

Preferably an electrical filter is used at the interface between the external distribution network and the internal network of the premises, e.g. a house, of a user to ensure that the two signals are separated. Such a
5 filter should have minimal effect on the normal domestic electricity supply.

The filter element of the present invention, which aims to reduce telecommunications signals entering the internal network of a users premises, preferably has no
10 more than 1 volt dropped across it whilst supplying a 100amp load from a 240v, 50HZ, single phase source.

Preferably the network conditioning unit provides impedance matching between reception/transmission devices and the power network. Additionally the network
15 conditioning unit may carry full load or fault current at power frequencies whilst still carrying the voice and data signals.

In a further aspect, the present invention provides a method of signal transmission including input of a
20 telecommunication signal onto an electricity power transmission and/or distribution network from a telecommunications network, and subsequent reception of the signal.

Where signals are being transmitted along a polyphase (e.g. three phase) electricity power cable, the signal propagation may be between any or all of the phases and ground. In a preferred embodiment the signal is injected
5 between only one of the phases and ground, which also provides unbalanced transmission characteristics and the cable behaves as a pseudo coaxial transmission line.

Where signals are being transmitted along a single phase electricity distribution service cable a pseudo-coaxial
10 effect may also be obtained. Single phase cables may typically be either concentric or split-concentric. In the case of a split-concentric cable, means (such as a capacitive coupling between the parts of the split-concentric sheath) may be provided so that at the desired
15 frequency the cable behaves as a standard concentric cable. Thus a pseudo-coaxial effect is achievable and the cable provides an unbalanced transmission characteristic.

A wide range of different transmission techniques are
20 available for use with electricity power line communication each using various modulation methods including frequency, time and code division multiplexing. It has been determined that the spread spectrum method offers inherent security and good interference rejection
25 characteristics. These properties are achieved using a

large bandwidth and hence requires the design of a specific filter.

A large number of standard cordless telephone communication techniques may be suitable for effecting
5 signal transmission over a conditioned network. Suitable standards may be R-CDMA (Rockwell-Code Division Multiple Access), cordless telephone standards CT1 and CT2, AMPS, DECT (Digital European Cordless Telephone Standard), IS-54, GSM, Q-CDMA, and UD-PCS.

10 The network conditioning unit preferably includes a low pass filter comprising a main inductor arranged between a mains electricity input and a mains electricity output and connected at each end thereof to a signal input/output line which is arranged in parallel to the
15 mains electricity input and mains electricity output, the two connections including a first capacitor and a second capacitor each of a predetermined capacitance depending upon the portion of the frequency spectrum which is to be utilised for communications purposes.

20 In this arrangement the main inductor is operative to prevent communications signals from the signal input/output line from entering the domestic/industrial premises. This inductor is therefore preferably of a high inductance such as 10 μ H to 200 μ H for frequencies of

1MHz and above.

The first capacitor which connects the mains electricity input and the signal input/output line acts as a coupling capacitor to allow communication signals through from the
5 signal input/output line whilst attenuating all low frequency components at or about the main electricity supply frequency (ie., 50/60Hz).

The second capacitor arranged between the mains electricity output and the signal input/output line
10 provides a further attenuation of communication signals and is connected via the signal input/output line to ground.

In the event of failure of either the first or second capacitor each such capacitor is preferably provided with
15 a respective fuse arranged between the first or second capacitor and the signal's input/output line. Furthermore an additional safety precaution can be incorporated by provision of a second inductor arranged between the connections between the signal input/output
20 line and the first and second capacitors. This inductor has no effect on communication frequency signals but will provide a path to ground if the first capacitor develops a fault thereby allowing the first fuse to blow without allowing the power frequency signal onto the signal

input/output line.

The inductance of the main inductor depends upon the material of which it is made and the cross-section of the wire wound around the core. The 10 μ H inductance
5 previously specified is preferably a minimum and with use of better core material a higher inductance, for example of the order of 200 μ H, can be obtained. Alternatively, a number of inductors connected in series could be used.

The coupling capacitor has a capacitance preferably in
10 the range 0.01 to 0.50 μ F and the second capacitor linking the mains electricity output with the signal input/output line and ground has a capacitance preferably in the range of 0.001 to 0.50 μ F.

The second inductor arranged on the signal input/output
15 line preferably has a minimum inductance of approximately 250 μ H. This inductor therefore has no effect on communication frequency signals on the signal input/output line. The conductor used to construct the 250 μ H inductor should be of sufficient cross-sectioned
20 area to take fault current should the decoupling capacitor fail to short circuit condition.

Preferably, any spurious of self resonance in the inductive or capacitive elements are avoided. As the

lower cut off frequency of the conditioning unit is increased the minimum values of inductance and capacitance may be proportionally reduced.

In a preferred embodiment the filter is assembled in a screened box so as to provide a good earth and prevent radiation of the communication signals.

Embodiments of the present invention will now be described with reference to the accompanying drawings in which:

10 Fig. 1 is a schematic diagram of a part of a network according to aspects of the present invention;

Fig. 2 is a schematic diagram of a first transmission system for a network according to the present invention;

Fig. 3 is a schematic diagram of a second transmission system for a network according to the present invention;

Fig. 4 is a schematic diagram of a third transmission system for a network according to the present invention;

Fig. 5A is a cross section through a typical three phase cable;

Fig. 5B is a section through a typical coaxial cable;

Fig. 6 is a preferred embodiment of a network conditioning unit according to an aspect of the present invention;

- 5 Fig. 7 is a second embodiment of a network conditioning unit according to an aspect of the present invention;

Fig. 8 is a plan view of a network conditioning unit;

Fig. 9 is a view of a circuit board for the network conditioning unit of Fig. 8.

- 10 Fig. 10 is a schematic diagram of a network conditioning unit according to the present invention.

Fig. 11 is a schematic diagram of a network conditioning unit according to an aspect of the present invention;

- 15 Figs. 12A, 12B and 12C show sectional views through a concentric, split-concentric and pseudo-concentric cable respectively; and

Fig. 13 shows a hybrid network according to the present invention.

Fig. 1 shows generally a network 40. Mains electricity enters the network from an 11kv transmission line 42, via a transformer 44 and onto a 415v three phase network 46. The 415v three phase network is supplied to a number of
5 locations, such as buildings 48. Each of these buildings may receive only a single phase electricity supply or alternatively may receive a three phase power supply.

Voice and data signals may be injected into the network
10 (or alternatively received from the network) to/from a telecommunications network at an injection point 50, to be transmitted and/or received by users in the premises 48. These signals may be narrow bandwidth e.g. telephony signals, or broadband e.g. television signals, as desired
15 - depending on the attenuation and distance to be travelled along the power distribution network.

In order to separate the voice and data communication signals from the low voltage high amplitude power signal each signal source and/or destination is provided with a
20 network conditioning unit 52. This network conditioning unit includes a low pass filter for separating out the two signals.

A further (high current) conditioning unit 51 may be fitted between the electricity and distribution

transformer 44 and the injection point 50 in order to further remove transformer noise from the condition network 40. The unit 51 is fitted with a high current inductor.

5 Fig. 13 illustrates a portion of a hybrid signal transmission network according to the present invention. A part of a cable 130 of a broadband telecommunication network (e.g. a coaxial or fibre cable) is illustrated running (for the purposes of this example) parallel to an
10 e.g. 3 phase electricity distribution cable 132. The electricity distribution network 132 may also carry telecommunication signals of suitable carrier frequency and bandwidth, as described elsewhere in this specification and that of PCT/GB93/02163. The
15 telecommunications network 130 carries broadband telecommunication signals e.g. television signals.

The telecommunication signals e.g. television signals, which may be analogue and/or digital format, are input from the telecommunications network 130 onto a portion
20 134 of the electricity distribution network 132 via a conditioning unit 136. The conditioning unit 136 allows the telecommunication signals to be input onto the electricity cable 134 without either the telecommunication signals entering the electricity
25 distribution network 132 or the electricity signals

entering the telecommunications network 130.

Similarly telecommunication signals may be input onto the telecom network from the portion 134 of the electricity distribution network 132.

- 5 If necessary, a coaxial/fibre interface unit 138 and an amplifier (e.g. a broadband amplifier) may be used to interface between the telecommunications network 130 and the conditioning unit 136.

Preferably the portion 134 of the electricity
10 distribution network 132 is a single phase cable. This may be a concentric single phase cable or a split-concentric single phase cable set up to act as a pseudo-concentric cable as described with reference to Figs 12A, 12B and 12C. Typically, this single phase cable connects
15 a users premises 142 to the e.g. 3 phase electricity distribution network 132.

Located in or near the user premises 142 may be a second conditioning unit 144 which separates the telecommunication signals 146 from the electricity supply
20 148. Thus distribution of both electrical energy and broadband telecommunication signals is facilitated without mutual impairment and without the need for a further coaxial/fibre link between the telecommunications

network 130 and the user premises 142.

A plurality of such links may be made from the telecommunications network 130 to a corresponding plurality of users premises. Also, the
5 telecommunications network 130 may be connected directly to the broadband telecommunications signals transmitter, or alternatively may be connected via a radio or satellite link 150.

The conditioning unit(s) 136 may be sited e.g. at street
10 level, such as in a curb side pillar or vault and adjacent to the electricity service position within the customers premises. The conditioning unit(s) 142 may be sited, for example, near the customers premises or within the customers premises such as inside a HRC cut-out unit
15 and/or the electricity meter.

Fig. 2 shows a portion of a three phase network 40 into which and from which data signals may be transmitted and received using the network conditioning units 52. The cable of the network is clad i.e. is surrounded by a
20 sheath 41 e.g. along all or substantially all of its length. As an example, data signals could be transmitted onto the yellow phase of the network by network conditioning unit 52A i.e., the signal is applied between the yellow phase and earth as shown. The transmitted

data may then be received by any or all of conditioning units 52B, 52C and 52D which are connected to the yellow, red and blue phases respectively. In other words transmitted data may be picked up on any phase of the
5 cable, including the phases onto which the signals were not injected by the transmitting unit. This is due to the mutual capacitance between the phase conductors producing an effectively pseudo-coaxial nature of the three phase cable. As can be seen, data can be
10 transmitted and received by each unit.

Each phase of the network 40 is shown to include a transformer 43. Typically this is effected by a single three phase transformer for all three phases, and not by three separate single phase transformers - although the
15 latter may be possible.

Fig. 3 shows a portion of a three phase power network 40 into which and from which data signals may be transmitted and received using four network conditioning units 52. As shown, the data signals are transmitted across two
20 phases of the three phase network - in this case the red and blue phases.

If one or more phases are not in use (e.g. the yellow phase in Fig. 3), the non-used phase(s) may be terminated to provide an appropriate impedance. This may be done

using an "L" circuit i.e. a series inductor with a shunter capacitor on the transformer side. This provides an optimum impedance and ensures that an RF signal which is coupled between e.g. the red and yellow phases, is not
5 shunted down by a low impedance transformer connection. This is particularly useful if there is insufficient inductive reactance at e.g. the yellow phase transformer connection point.

In Fig. 4 an alternative transmission system to Fig. 2 is
10 shown, in which the data signals are transmitted across all three phases, i.e. blue, red and yellow, of the three phase network 40.

Fig. 5A shows a simplified cross section of a three phase power cable 54, including red phase 56, yellow phase 58,
15 and blue phase 60. Data signals are transmitted between blue phase 60 and earth 62, and are injected into the network via network conditioning unit 52. At high frequencies, the mutual capacitance between the phases effectively produces a short circuit. Therefore, such a
20 transmission system gives a pseudo-coaxial characteristic, roughly equivalent to the coaxial cable shown in Fig. 5B. The mutual capacitance between any two of the phases in the three phase cable is shown schematically as 64 in Fig. 5A - similar mutual
25 capacitance exists between other parts of phases.

The basic elements of a network conditioning unit 101 according to one aspect of the present invention are illustrated in Fig. 11. The conditioning unit can be considered to be equivalent to a low pass filter 100 and
5 a coupling capacitor element 102 (which can be considered to be a high pass filter element).

The low pass filter element 100 allows mains power to be supplied from the distribution network to a consumer whilst preventing high frequency communication signals
10 from entering the consumers premises. A coupling capacitor, or high pass filter element, 102 is provided to couple the high frequency communication signals onto the distribution network whilst preventing the mains power from entering the communications apparatus.

15 The conditioning unit components may be fitted into e.g. an electricity meter case located in a consumer's premises, or possibly may be set into a compartment at the rear of such a meter. Alternatively the necessary components may be located in e.g. a customer's high
20 rupturing capacity (HRC) fuse or cut-out unit.

Referring to Fig. 6, an embodiment of a conditioning unit (essentially a filter) according to an aspect of the invention is indicated generally by the reference numeral 10 and is connected between a mains electricity input 12

and a mains electricity output 14. A signal input/output line 16 is also connected into the filter. The mains power line is a standard 50Hz mains electricity power supply providing a domestic electricity power source of
5 240v at a maximum current of 100 amps for normal usage.

The filter 10 is assembled into a metal box which prevents radiation of the communication signals to externally located appliances and which provides a connection 18 to earth for the signal input/output line
10 16. The filter 10 includes a first or main inductor 20 formed of 16mm^2 wire wound on a 10mm diameter, 200mm long ferrite rod with 30 turns of wire therearound. This provides an inductance of approximately $50\mu\text{H}$. This may be a minimum for the signal characteristics utilised.
15 The use of better materials or a plurality of series inductors would increase the inductance of the inductor up to, for example, approximately $200\mu\text{H}$.

Each end of the main inductor 20 is provided with a connection to the signal input/output line 16. A first
20 connection 22 between the mains electricity input 12 and signal input/output line 16 comprises a first or coupling capacitor 24 having a capacitance of between 0.01 and $0.50\mu\text{F}$, and preferably around $0.1\mu\text{F}$. This coupling capacitor 24 is connected to a first fuse 26
25 which is arranged to blow in the event of failure or a

fault developing in capacitor 24.

A second connection 28 includes a second capacitor 30 having a capacitance of between 0.001 and 0.50 μ F, preferably around 0.1 μ F. This capacitor provides further
5 attenuation of the communication signals by shorting to the earth or ground 18. A second fuse 32 is provided to blow if a fault develops in the second capacitor 30 thereby preventing further unit damage.

The signal input/output line 16 includes a second
10 inductor 34 having an inductance of approximately 250 μ H minimum. This inductor is provided as a damage limiter in the event of failure of the coupling capacitor 24. In the event of such failure this inductor provides a path to the ground 18 for the 50Hz mains electricity power
15 frequency thereby blowing fuse 26. The inductor has no effect on the communication frequency signals present on the signal input/output line 16.

Fig. 7 shows a second embodiment of a filter according to an aspect of the present invention. The filter 70
20 includes a pair of inductors L1, L2 arranged in series between a mains electricity input 72 and a mains electricity output 74. A preferred value for L1 and L2 is approximately 16 μ H. Connected between the RF input line 80 and the mains input 72 is a first fuse F1 and

capacitor C1, and connected between the RF input 80 and ground is a third inductor L3, which acts as an RF choke and has a typical value of 250 μ H.

Connected in a similar fashion between the connection point of L1 and L2 and ground is a second fuse F2 and second capacitor C2. Connected between the mains electricity output 74 and ground is a third fuse F3 and third capacitor C3. Typical value for the capacitors is around 0.1 μ F and for the fuses approximately 5 amps HRC (high rupturing capacity).

Turning to Fig. 8 a typical housing arrangement for a network conditioning unit according to an embodiment of the present invention is shown. The main inductors L1 and L2 are housed within a shielding box 90. Various connections are shown, including a communication interface port 92 to which a user's communication equipment would normally be connected. However, as shown in Fig. 8, this port may be terminated in an impedance matching port terminator 94.

Fig. 9 shows a circuit board 96 which fits inside the unit 90 of figure 8 and houses the rest of the circuitry for the network conditioning unit of figure 7. Connections A, B, C, D and E are shown which connect to the appropriate points of the box shown in figure 8.

Fig. 10 is a schematic representation of a network conditioning unit 52, showing the various building blocks 80-86 of the network conditioning element. To design a suitable network conditioning unit, the circuits represented by blocks 81 and 86 should be high-impedance elements over the required communications frequency spectrum (eg. 1MHz and above) and low impedance elements at frequency of mains electricity supply (ie. 50/60HZ) ie. these elements are inductors. Similarly blocks 80 and 82 should be low impedance coupling elements over the required communications frequency spectrum and high impedance isolating elements at the frequency of the mains electricity supply ie. they are capacitors.

HRC (high rupturing capacity) fault current limiting fusible safety links (84 and 85) are provided in series with elements 80 and 82. An additional impedance matching network 83 may be included for connection to a communications port. This element may be external to the network conditioning unit 52.

The optimum values of items 81, 80, 82 and 86 will be dependant upon factors including:-

a) The required frequency range over which the network is to be conditioned.

- b) The unit length of the network which is to be conditioned.
- c) The number and types of loads which may be encountered on the network.
- 5 d) The characteristic impedance of the network phase conductors with respect to earth ie. conductor outer electrical sheath.
- e) The impedance of the communications interface devices.

The network conditioning unit may be filled with air,
10 inert gas, resin compound or oil depending upon the location and load and/or fault current ratings of the conditioning unit. Also it may be sited indoors, pole mounted, buried underground or inserted in street lamp columns.

- 15 Similarly items 81 and 86 may comprise of a number of individual inductors in series, and if no interconnection is required, for example, on a street light, items 84, 80, 83 and 86 may be omitted.

Items 80 and 82 may comprise of a number of capacitors in
20 series and/or parallel configuration depending upon working voltages encountered ie. 240, 415, 11kV, 33kV

etc. Alternatively, or additionally, items 80 and 82 may comprise of two or more capacitors in parallel in order to overcome, for example, deficiencies in capacitor design when conditioning a network over a relatively wide
5 frequency range, for example 50 MHz to 500 MHz.

Furthermore, items 81, 85 and 82 of the network conditioning unit may be cascaded if required. In a typical design, the greater the number of cascaded elements the sharper will be the roll off response of the
10 filter and the greater its attenuation.

Figs. 12A, 12B and 12C show sectional views through a single phase concentric, split-concentric and "pseudo" - concentric cables respectively. A typical concentric single phase cable (as illustrated in Fig. 12A) consists
15 of a central metallic conductor core (typically aluminium) 110 surrounded by an insulating layer 112 (typically PVC). Around the insulating layer 112 are laid a plurality of metallic conductors 114 (typically copper) over which lies an insulating and protective
20 sheath 116 (typically PVC). In use the neutral and earth are combined in the outer sheath of metallic conductors 114.

A split-concentric cable (as illustrated in Fig. 12B) is similar to the concentric cable except that the outer

layer of metallic conductors 114 is split into two portions - e.g. an upper portion 115 and a lower portion 117. These portions are divided by insulators 118, 120 and in use the neutral and earth are split so that one
5 portion of the outer metallic sheath carries only one of them.

In order to maintain a pseudo-coaxial effect in the split-concentric service cables at the desired transmission frequencies (e.g. above 1MHz) one or more
10 capacitors 122 may be connected between the upper and lower portions 115, 117 of the outer metallic sheath 114. These capacitor(s) may be fitted e.g. at the termination and/or conditioning points of the cable.

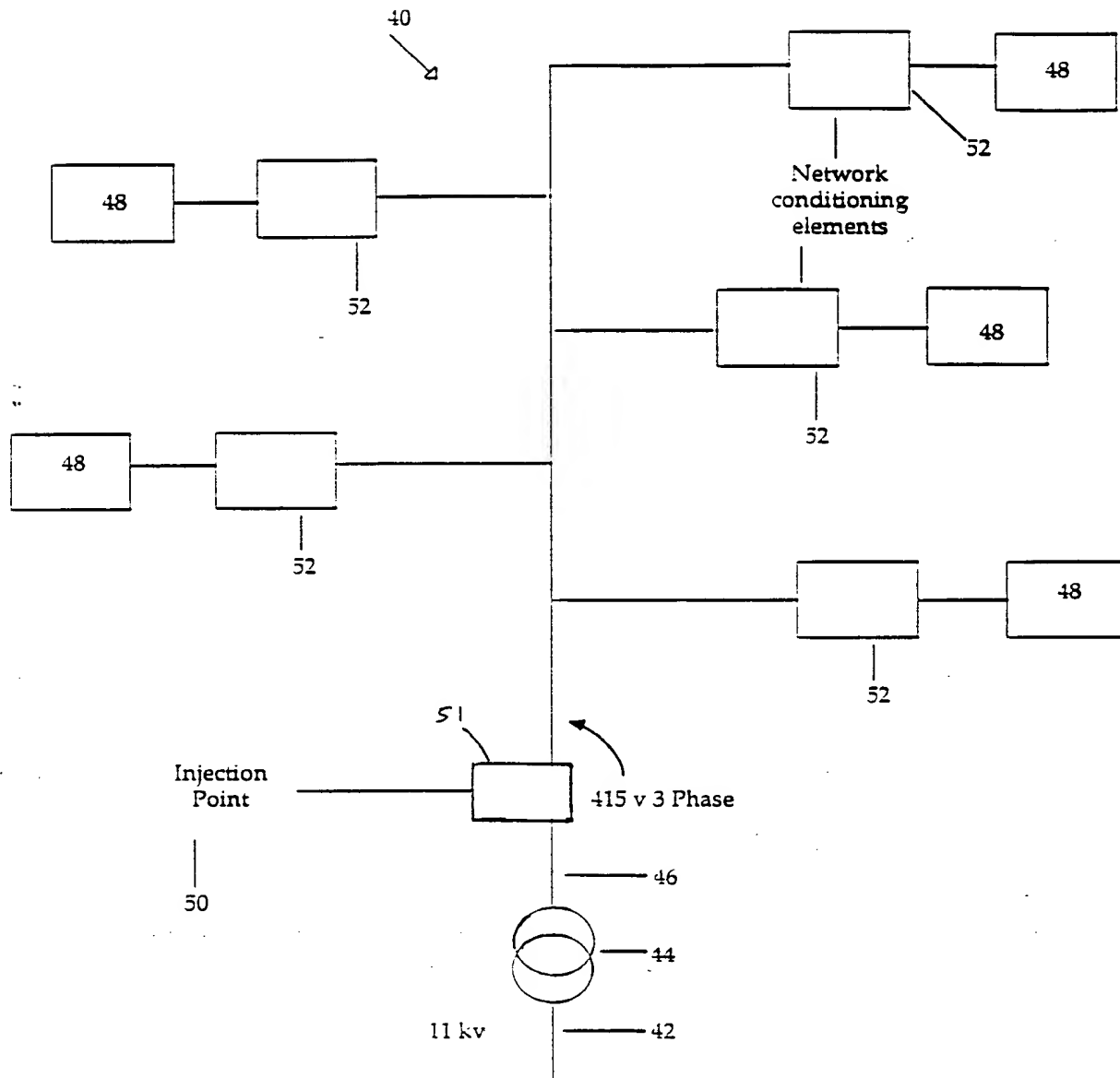
It will be seen from the foregoing that a simple filter
15 is provided which effectively separates signals having a frequency spectrum indicative of radio communication signals from those of standard mains electricity power supply without significant loss of power or quality in either signal. Thus the electricity distribution and/or
20 transmission networks can be used for both the provision of electricity supply and the propagation of broadband telecommunication signals which may be analogue and/or digital in format.

The use of such a filter at each consumer supply point in

a low voltage underground electricity distribution network provides a conditioned network suitable for the transmission of high frequency communication signals together with the distribution of 50Hz, 240v single and
5 415v, three phase electricity supplies. The provision of such a conditioned network constitutes a further aspect of the invention.

The invention is not confined to the foregoing details and variations may be made thereto within the scope of
10 the invention.

FIG.1



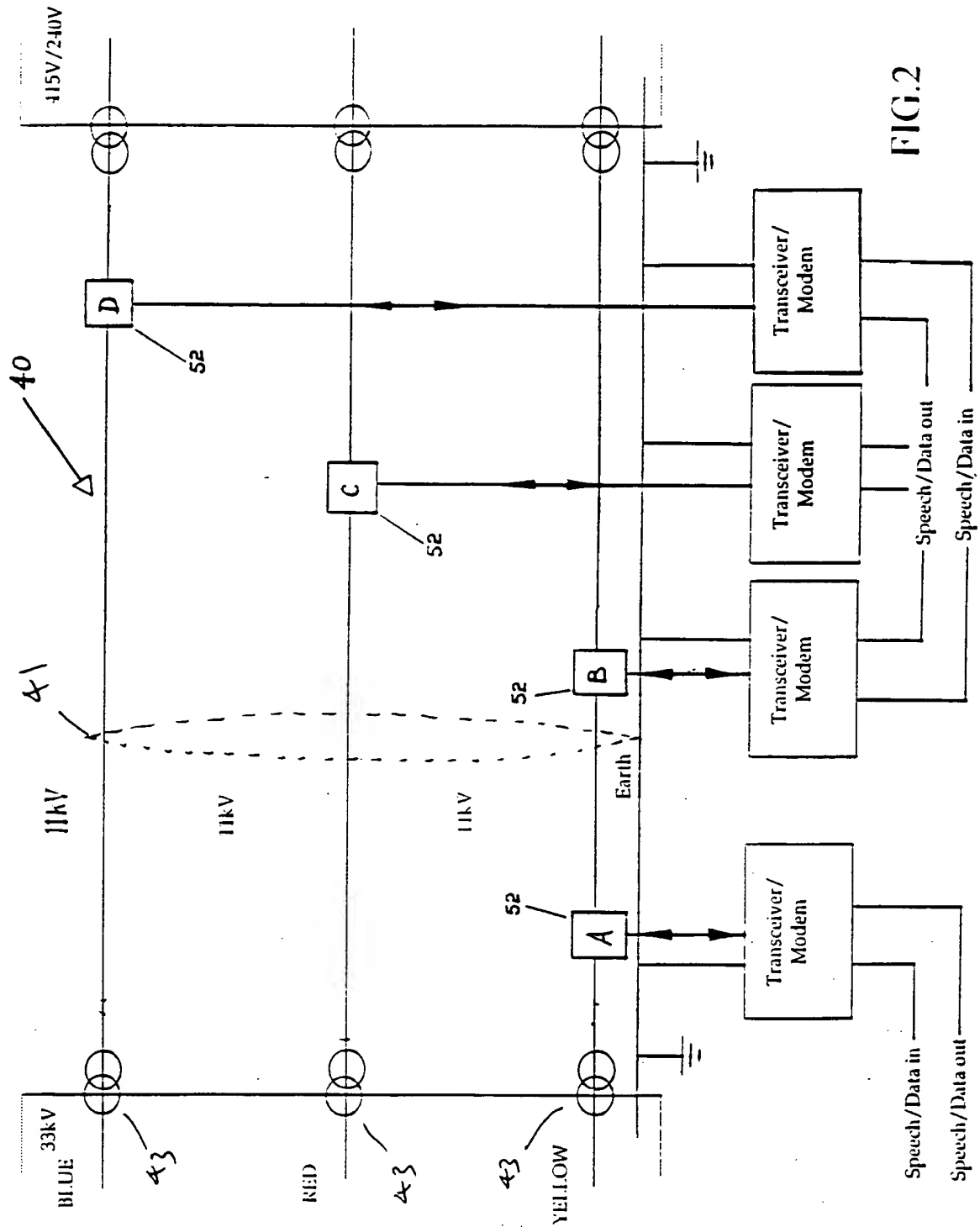


FIG.3

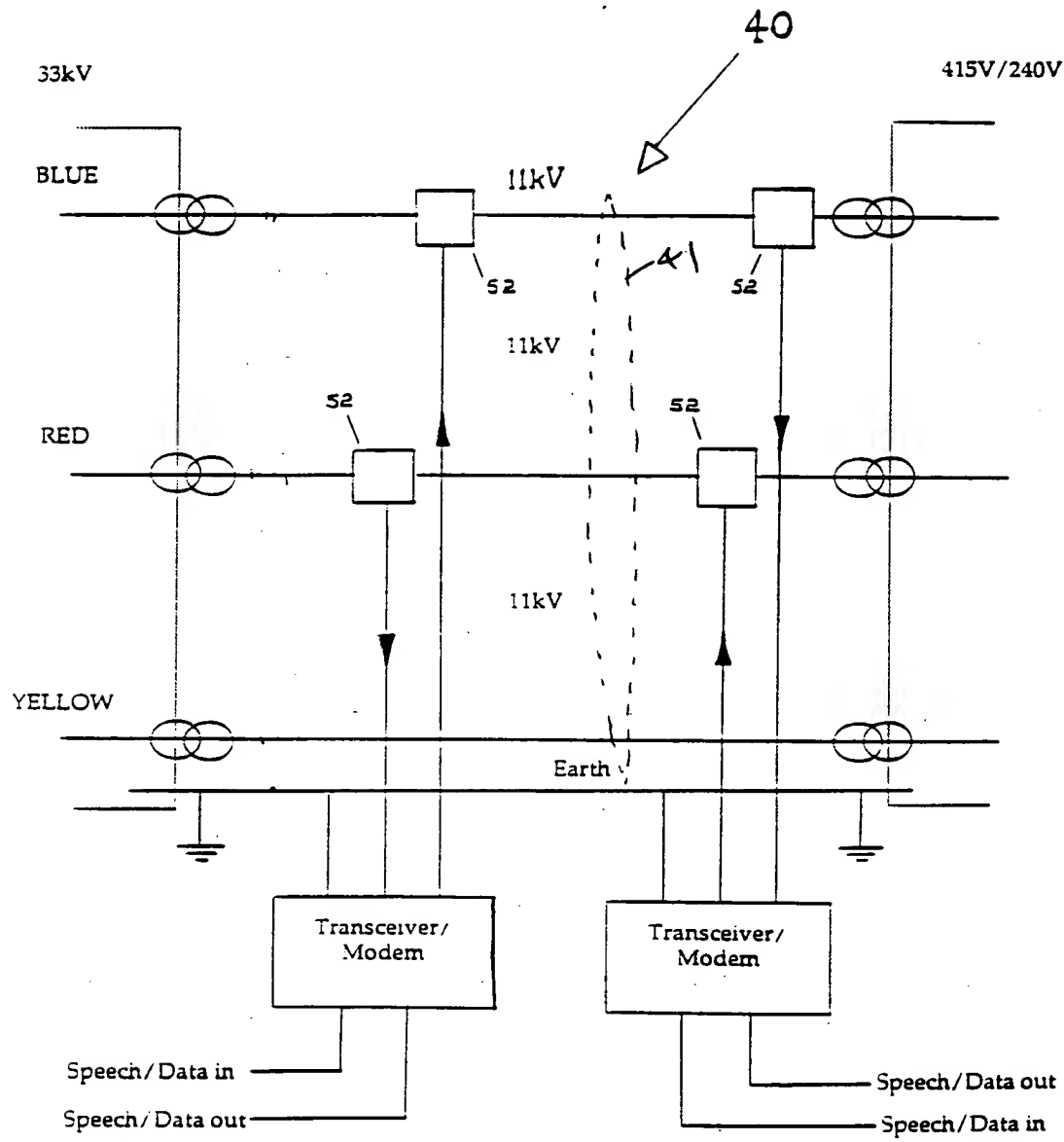
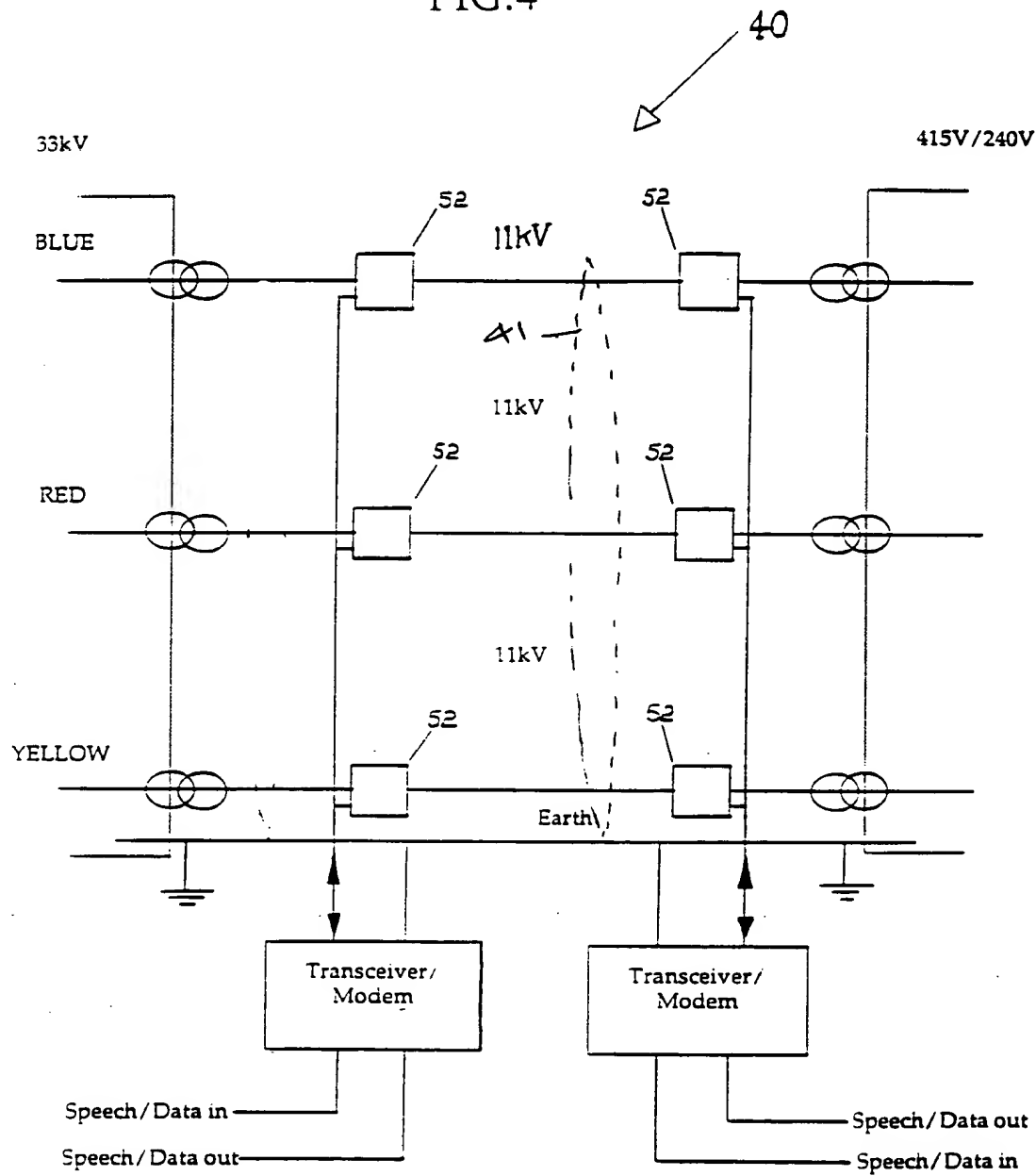


FIG. 4



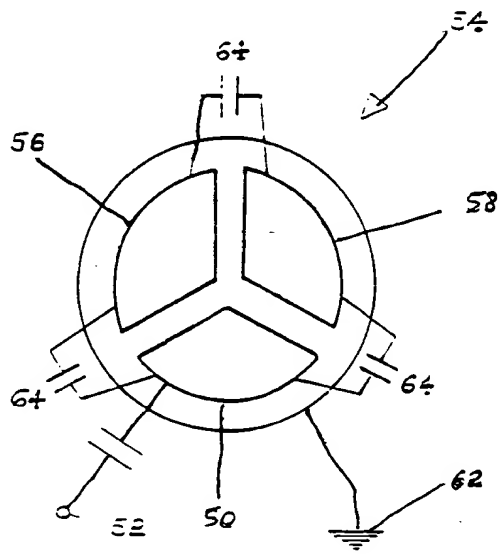


FIG. 5 A

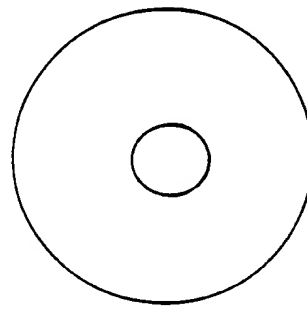


FIG. 5 B

FIG. 6

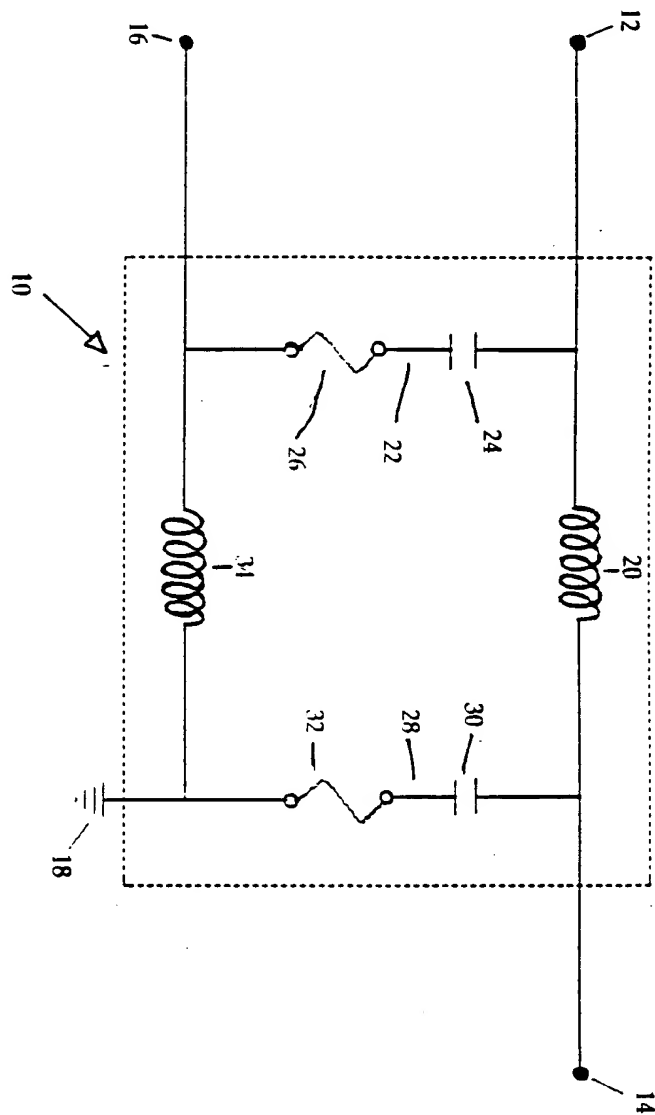
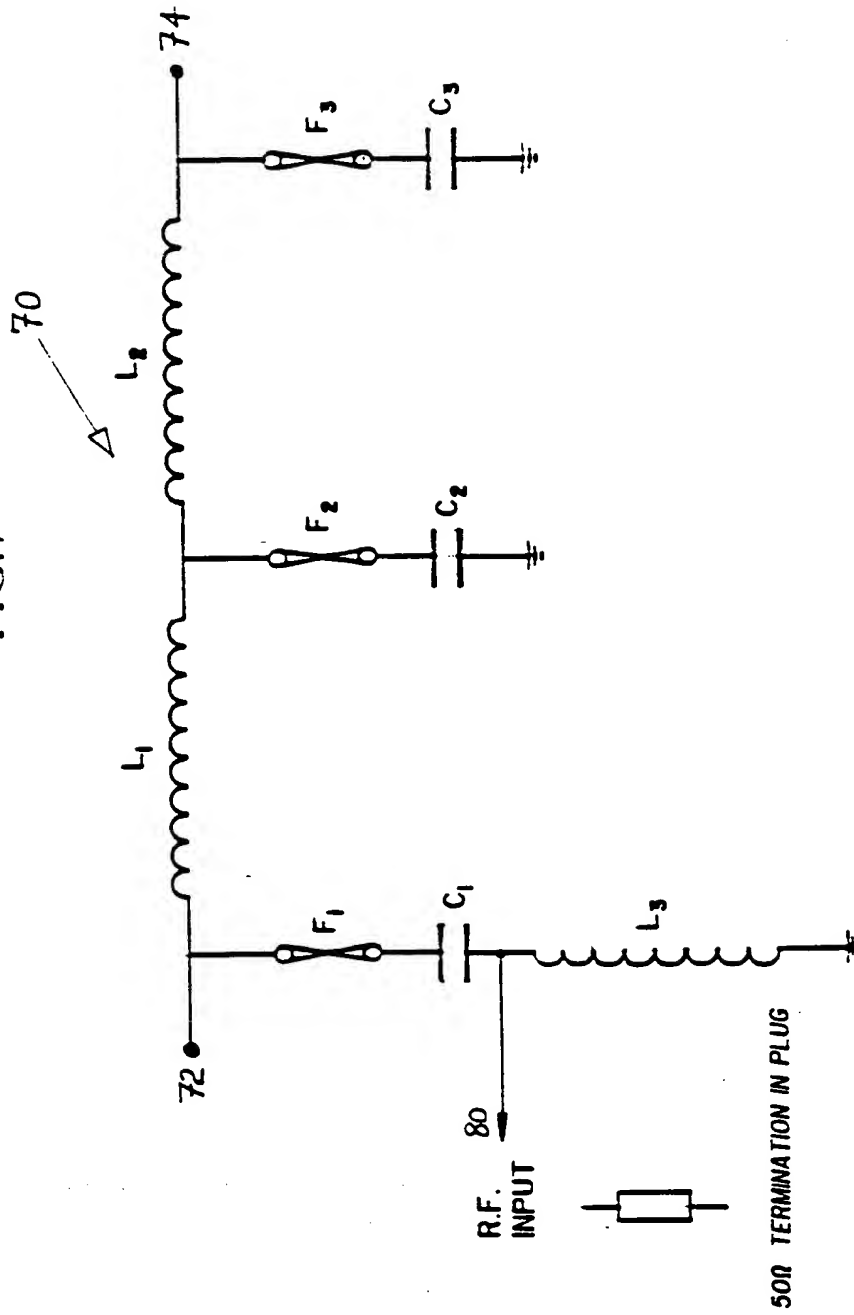


FIG. 7



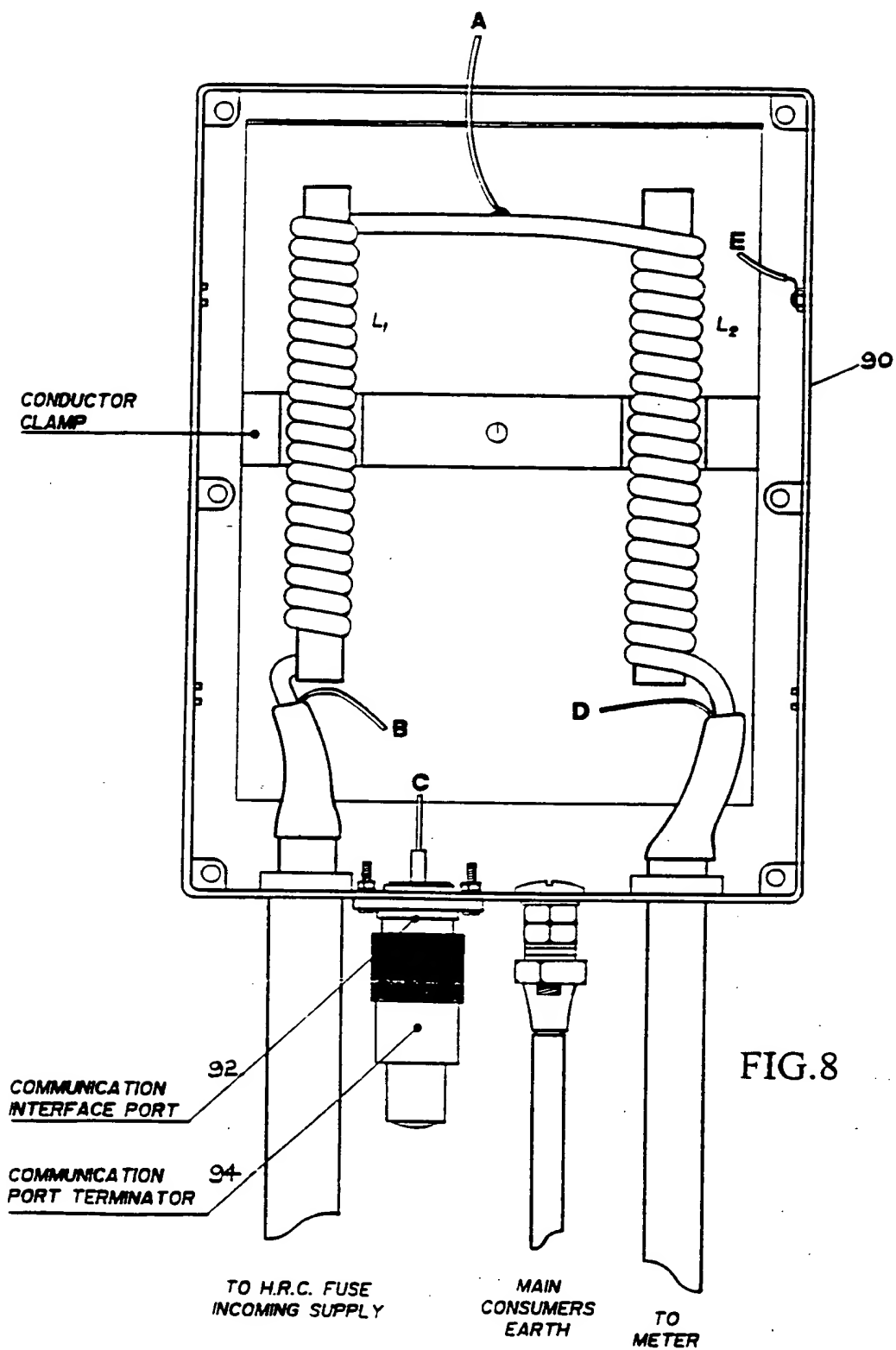
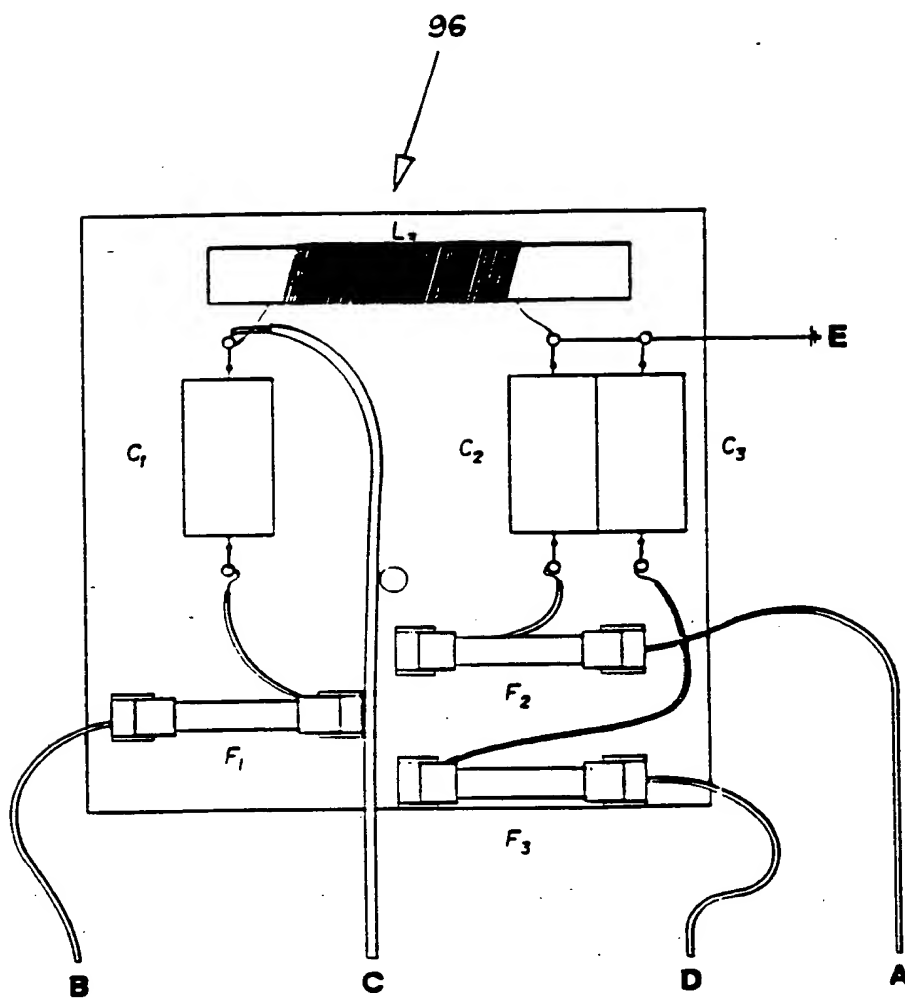


FIG.9.



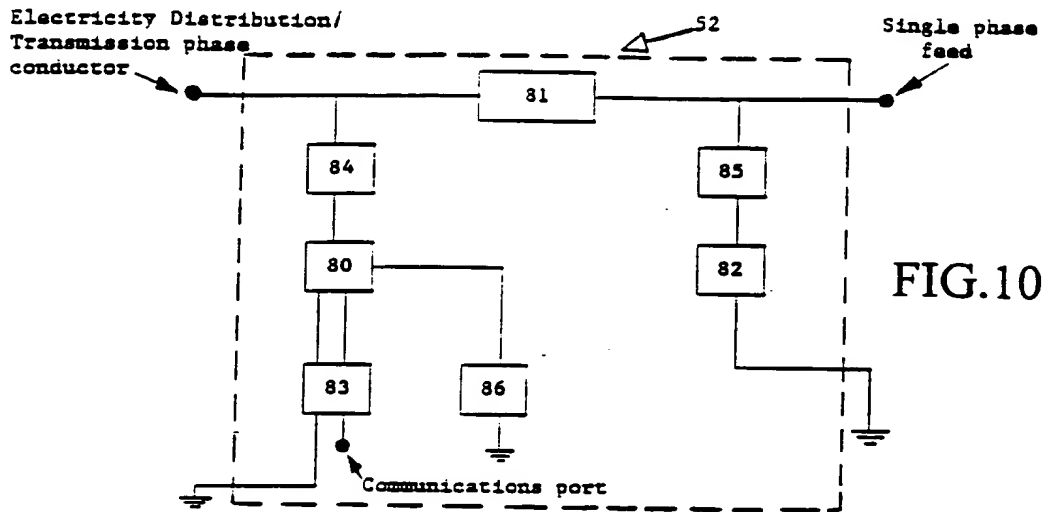


FIG.10

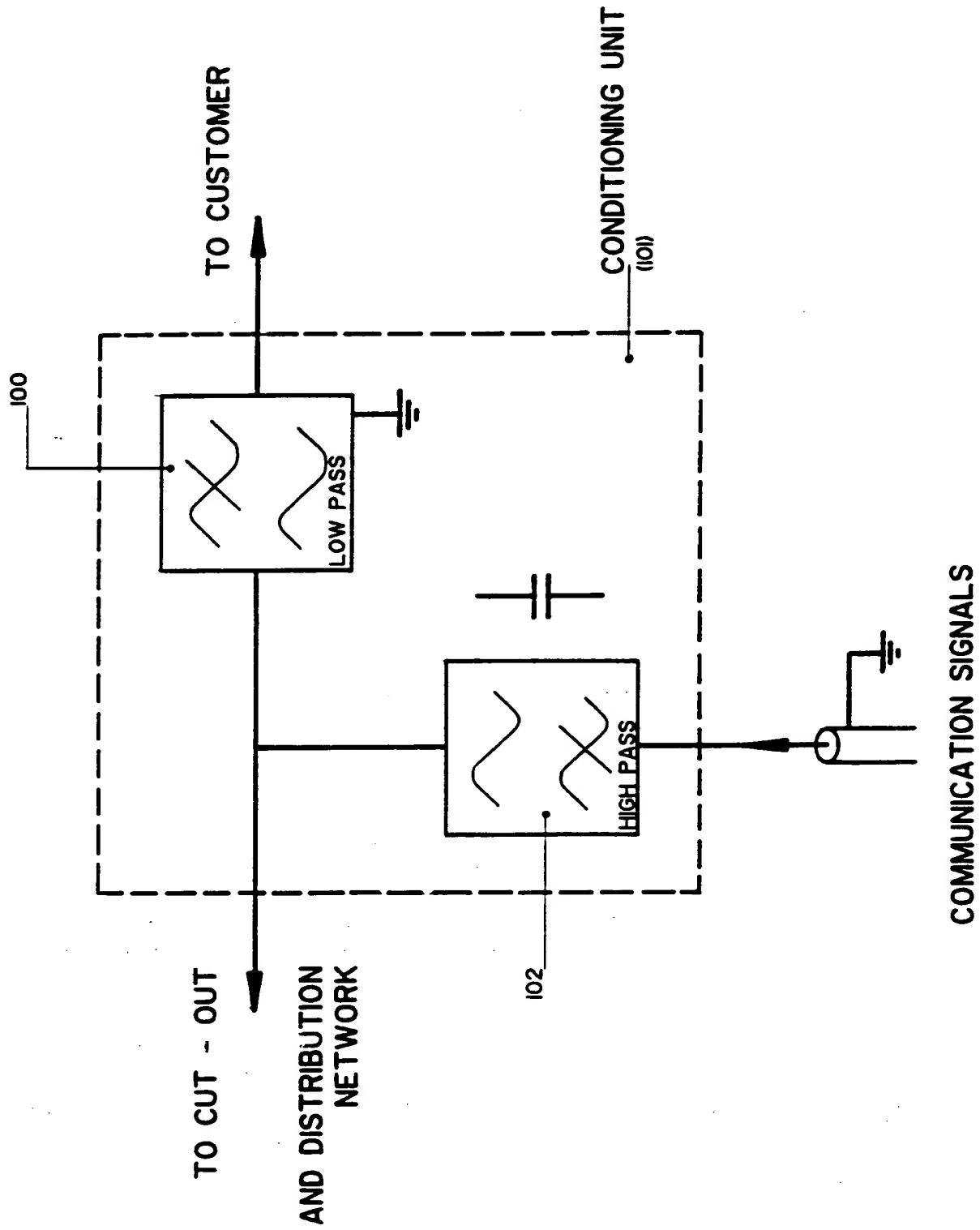


FIG II

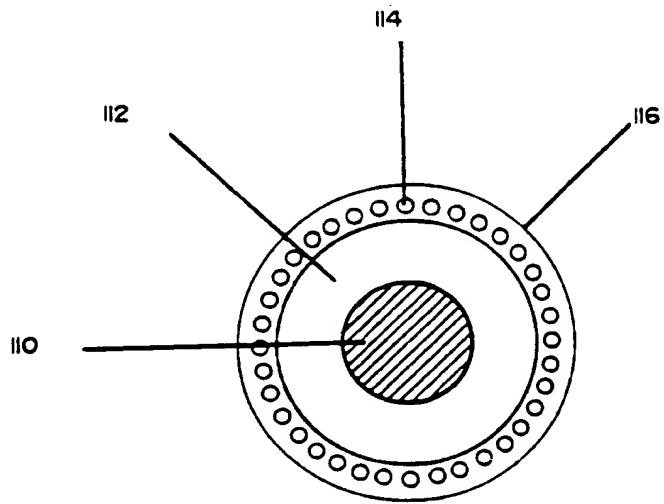


FIG 12A

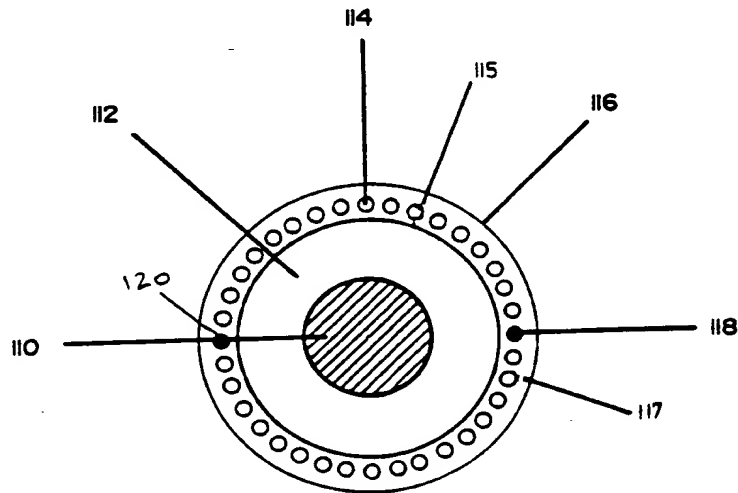


FIG 12B

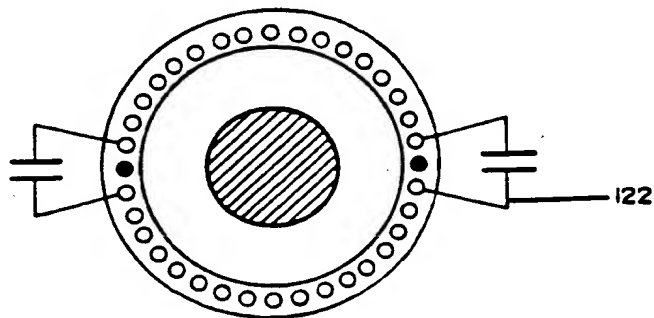


FIG 12C

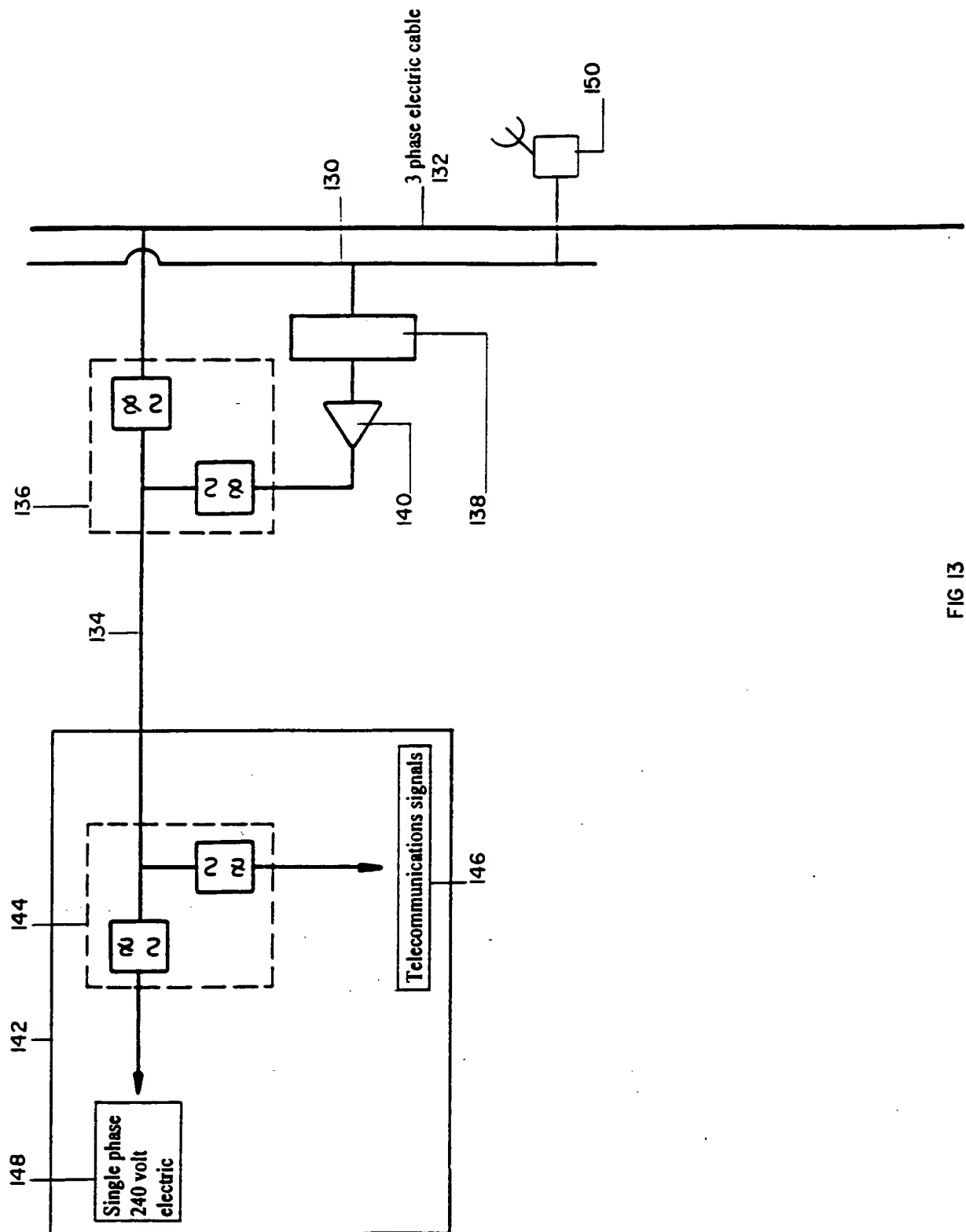


FIG 13

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